

Claims

What is claimed is:

1. An implantable power module comprising:
a hermetically sealed biocompatible case;
an electrochemical energy storage device housed within said case;
a power management circuit housed within said case;
a couple for remotely communicating with said power module;
said couple electrically connected to said power management circuit;
and at least one connector for functionally interconnecting said electrochemical energy storage device to an implantable medical device.
2. The implantable power module of claim 1 wherein said power management circuit comprises a data processing circuit.
3. The implantable power module of claim 1 further comprising a homing device for locating said power module after it is implanted.
4. The implantable power module of claim 1 wherein said electrochemical energy storage device comprises at least one primary battery.
5. The implantable power module of claim 1 wherein said electrochemical energy storage device comprises at least one rechargeable battery.
6. The implantable power module of claim 5 wherein said electrochemical energy storage device further comprises at least one primary battery.
7. The implantable power module of claim 1 wherein said electrochemical energy storage device comprises at least one capacitor.
8. The implantable power module of claim 1 wherein said at least one connector comprises a combined power and data connector.

9. The implantable power module of claim 1 wherein said at least one connector comprises at least one power connector, and at least one data connector.
10. The implantable power module of claim 5 wherein said couple comprises a secondary inductive coil interoperatively connected to said rechargeable battery wherein a fluctuating electromagnetic field generates a current in said secondary inductive coil effecting recharging of said rechargeable battery.
11. The implantable power module of claim 10 wherein said power management module controls said recharging.
12. The implantable power module of claim 10 wherein said secondary inductive coil at least partially surrounds said electrochemical storage device.
13. The implantable power module of claim 5 wherein at least a portion of said rechargeable battery is surrounded with a ferrous magnetic material.
14. The implantable power module of claim 13 wherein said a ferrous magnetic material comprises ferrite.
15. The implantable power module of claim 5 wherein at least a portion of said power management circuit is surrounded with a ferrous magnetic material.
16. The implantable power module of claim 15 wherein said a ferrous magnetic material comprises ferrite.
17. The implantable power module of claim 1 wherein said power management circuit manages the safety and operation of said implantable power module.
18. The implantable power module of claim 17 wherein said power management circuit senses and responds to one or more of the following conditions: overcharging, over-discharging, excessive battery temperature, abnormal voltage, and abnormal current.

19. The implantable power module of claim 18 wherein said power management circuit response comprises disconnecting said electrochemical energy storage device from at least one electrical circuit.
20. The implantable power module of claim 19 wherein said response comprises connecting the terminals of said energy storage device to an energy-drain circuit to rapidly deplete the energy content of said energy storage device.
21. The implantable power module of claim 20 wherein said energy-drain circuit comprises at least a portion of said couple.
22. The implantable power module of claim 21 wherein said couple comprises a secondary inductive coil.
23. The implantable power module of claim 20 further comprising a heat absorption material in thermal contact with said energy drain circuit.
24. The implantable power module of claim 23 wherein said heat absorption material comprises a phase change material having an endothermic phase change at about between 50°C to 80°C.
25. The implantable power module of claim 24 wherein said heat absorption material comprises paraffin.
26. The implantable power module of claim 1 further comprising a heat absorption material in thermal contact with said electrochemical energy storage device.
27. The implantable power module of claim 26 wherein said heat absorption material comprises a phase change material having an endothermic phase change at about between 50°C to 80°C.

28. The implantable power module of claim 26 wherein said heat absorption material comprises paraffin.
29. The implantable power module of claim 26 wherein said heat absorption material is located external to said electrochemical energy storage device.
30. The implantable power module of claim 26 wherein said heat absorption material is located within said electrochemical energy storage device.
31. The implantable power module of claim 1 wherein said hermetically sealed biocompatible case comprises at least one of the following: metal and ceramic.
32. The implantable power module of claim 31 wherein said metal comprises titanium or an alloy of titanium.
33. The implantable power module of claim 1 wherein said medical device is contiguously attached to said power module and wherein said connecting means comprises electrical contacts contained within an external hermetic plug.
34. The implantable power module of claim 1 wherein said medical device is remotely located to said power module and wherein said connecting means comprises at least one external hermetic plug and wires interoperatively connecting said power module and said biomedical device.
35. The implantable power module of claim 34 wherein said wires conduct power to operate said medical device and transmit data between said medical device and said implantable power module.
36. The implantable power module of claim 1 further comprising a means for communicating status remotely.

37. The implantable power module of claim 36 wherein said means for communicating comprises signals carried via said couple.
38. The implantable power module of claim 37 wherein said couple comprises an inductive coil.
39. The implantable power module of claim 36 wherein said means for communicating comprises a radio frequency transmitter and a radio frequency receiver.
40. The implantable power module of claim 36 wherein said means for communicating comprises a light wave transmitter and a light wave receiver.
41. The implantable power module of claim 1 further comprising a means for remotely controlling said power module.
42. The implantable power module of claim 41 wherein said means for controlling said power module comprises signals carried via said couple.
43. The implantable power module of claim 42 wherein said couple comprises an inductive coil.
44. The implantable power module of claim 41 wherein said means for controlling said power module comprises a radio frequency transmitter and a radio frequency receiver.
45. The implantable power module of claim 41 wherein said means for controlling said power module comprises a light wave transmitter and a light wave receiver.
46. The implantable power module of claim 1 wherein said power management circuit further comprises said homing device for locating said power module.
47. The implantable power module of claim 3 wherein homing device for locating said power module after it is implanted comprises magnetic material.

48. The implantable power module of claim 3 wherein said homing device for locating said power module after it is implanted comprises at least one passive transponder.
49. The implantable module of claim 48 wherein said at least one passive transponder comprises at least one microchip.
50. The implantable power module of claim 3 wherein said homing device for locating said power module after it is implanted comprises at least one active transponder.
51. The implantable power module of claim 50 wherein said at least one active transponder comprises at least one microchip.
52. The implantable power module of claim 3 wherein said homing device for locating said power module after it is implanted comprises at least one radio frequency transmitter.
53. A homing device for locating said power module after it is implanted of claim 52 further comprising an initiator circuit responsive to a signal from outside said power module, wherein said initiator circuit switches on said radio frequency transmitter upon receiving said signal from outside said power module.
54. The homing device for locating said power module after it is implanted of claim 53 wherein said signal from outside said power module comprises a radio frequency signal.
55. The homing device for locating said power module after it is implanted of claim 53 wherein said signal from outside said power module comprises a magnetic field.
56. The homing device for locating said power module after it is implanted of claim 53 wherein said signal from outside said power module comprises an audio signal.
57. The homing device for locating said power module after it is implanted of claim 53 wherein said signal from outside said power module comprises a light signal.

58. The implantable power module of claim 3 wherein said homing device for locating said power module after it is implanted comprises a metal object wherein said metal object is detectable transcutaneously with a metal detector.
59. The implantable power module of claim 3 wherein said homing device for locating said power module after it is implanted comprises a light-producing device detectable transcutaneously.
60. The implantable power module of claim 59 wherein said light-producing device comprises at least one light-emitting diode.
61. The implantable power module of claim 59 wherein said light producing device emits light in the approximately 400 to 700 nm range.
62. The implantable power module of claim 59 wherein said light producing device emits light in the approximately 0.8 to 2.5- μm range.
63. The implantable power module of claim 3 wherein said homing device for locating said power module after it is implanted comprises radioactive material which can be detected transcutaneously.
64. The implantable power module of claim 3 wherein said homing device for locating said power module after it is implanted comprises a biocompatible tendril or protrusion extending from said secondary charger coil intercutaneously such that it may be detected by touch.
65. The implantable power module of claim 3 wherein said homing device for locating said power module after it is implanted comprises a biocompatible tendril or protrusion extending transcutaneously from said secondary charger coil to outside the patient's body.

66. The implantable power module of claim 1 and further comprising at least one additional connector for coupling said electrochemical energy storage device to at least one additional medical device.
67. The implantable power module of claim 1 wherein said connector for coupling said electrochemical energy storage device to a medical device is further characterized by being detachably connectable to said medical device.
68. The implantable power module of claim 1 wherein said implantable module is monolithic.
69. The implantable power module of claim 1 wherein said implantable module comprises at least two submodules operatively interconnected by electrical conductors.
70. The implantable power module of claim 69 wherein a first submodule contains at least said couple, said first submodule located remotely from a second submodule, said second submodule containing one or more additional components comprising said implantable power module, said first submodule interconnected with second submodule by electrical conducting wires.